SYMPOSIUM ON SPACE DEBRIS (A6)
Orbit Determination and Propagation (9)

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MAPPING SENSORS MEASUREMENTS TO RESIDENT SPACE OBJECTS ENERGY AND STATE PARAMETERS SPACE VIA EXTREME LEARNING MACHINES

Abstract

Due to the growing amount of orbital debris, over the past few years, Space Domain Awareness (SDA), has become of critical component of any space-based operation. Whereas The U.S. Space Object Catalog currently lists approximately 15,000 trackable objects, the total population is thought to exceed 20,000 objects larger than 10 cm. In order to protect valuable space assets, it is necessary to observe, understand, and predict the behavior of objects in orbit around the Earth. However, characterizing the behavior of Resident Space Objects (RSOs) require a thorough understanding of the functional relationship between sensor measurements and object energy and state parameters. Such functional relationship is generally representative of the physical processes underlying the interaction between the RSO and its environment. Such processes can be modeled using a set of coupled dynamically linked models representing the evolution in time of the RSO energy and state parameters (e.g. energy state, angular momentum, absorbed, reflected and emitted energy). There is generally no closed-form, explicit representation of the relationship between measurements and RSO energy parameters which represents a major challenge. Moreover, in the context of RSO behavior characterization, even assuming that the energy and state parameters were determined, the following questions must be answered, i.e. 1)Given the knowledge of energy and state parameters for a set of RSOs, how can we identify patterns and identify physically-driven emerging behaviors? 2) How can we employ knowledge of energy and state parameters to effective classify the RSO and provide robust inference on its behavior? In this paper, we focus on the first problem, i.e. we aim at understanding and characterizing the functional relationship between sensor measurements and RSOs behavior by using a data-driven, physically-based approach where simulations of coupled physical models and RSO measurements can be employed to train a set of learning machines in a supervised fashion to 1) characterize the functional relationship between sensor measurements and RSO energy and state parameters, 2) Analyze patterns in the energy and state parameters space to identify emerging behavior for RSOs. We will employ physical models (e.g. orbital dynamical models coupled with attitude models, light curve models representing the reflected and absorbed energy) and a set of state-of-the-art Extreme-Learning Machines to train a set of neural networks for regression i.e., characterize the functional relationship between sensor measurements and RSO energy and state parameters.